The Utility of the Ozone Monitoring Instrument (OMI) HCHO & NO_2 in Air Quality Decision-Making Activities

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Aura provides information on 5/6 of EPA's Criteria Pollutants.

OMI NO_2 →

← *TES, MLS CO**

**Little info. on "nose-level" values.*

OMI SO_2 →

← *OMI, TES Ozone**

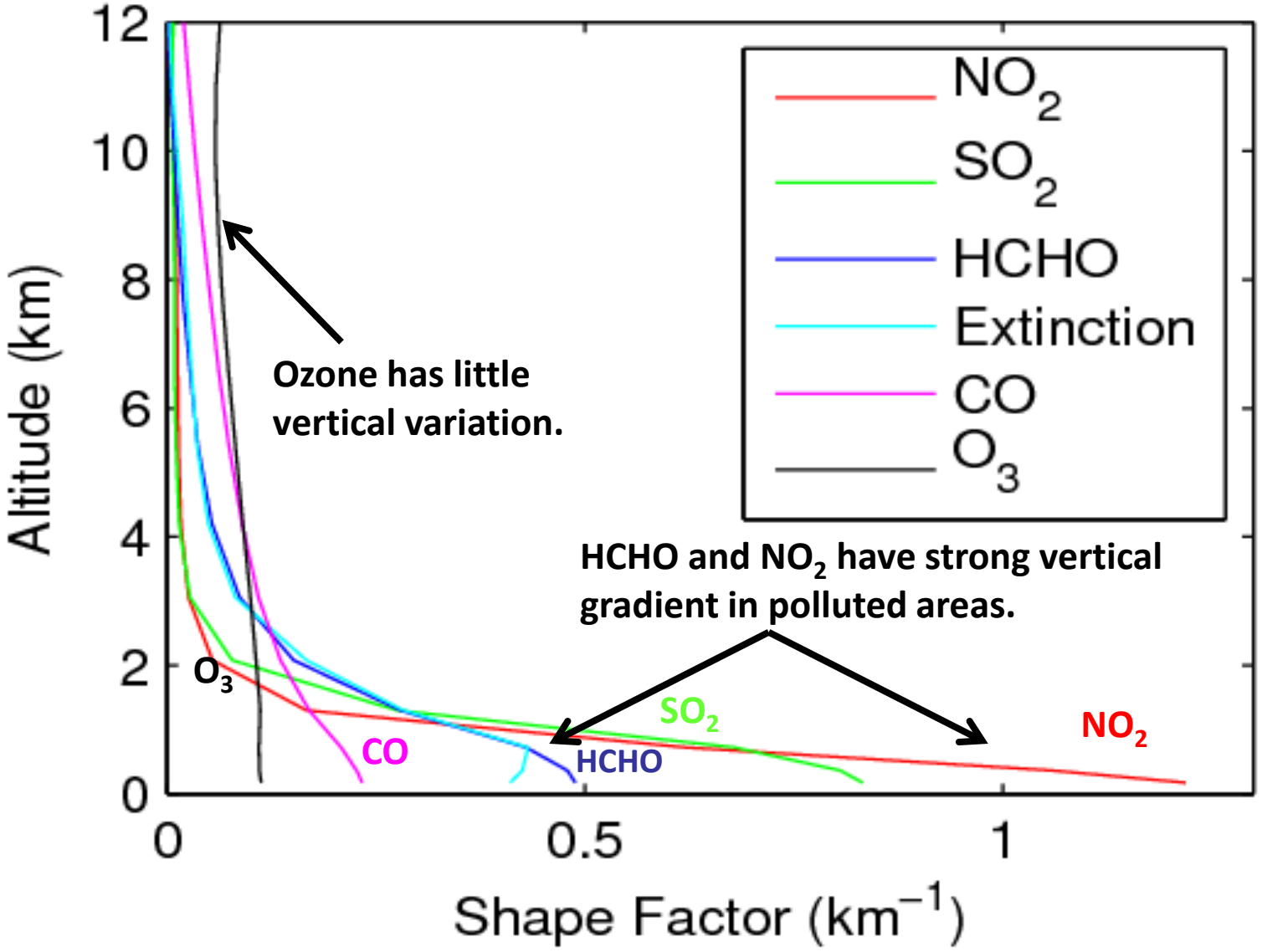
Aura →

← *OMI Aerosol Index***

***Aerosol Index is not a measure of PM2.5.*

OMI = Total Column Measurement

Pollutant Distributions in the Vertical

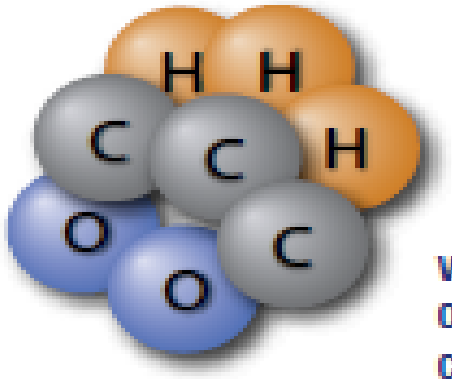


There is currently little information on "nose-level ozone", but we do have information on ozone precursors!

OMI NO_2 **OMI HCHO**

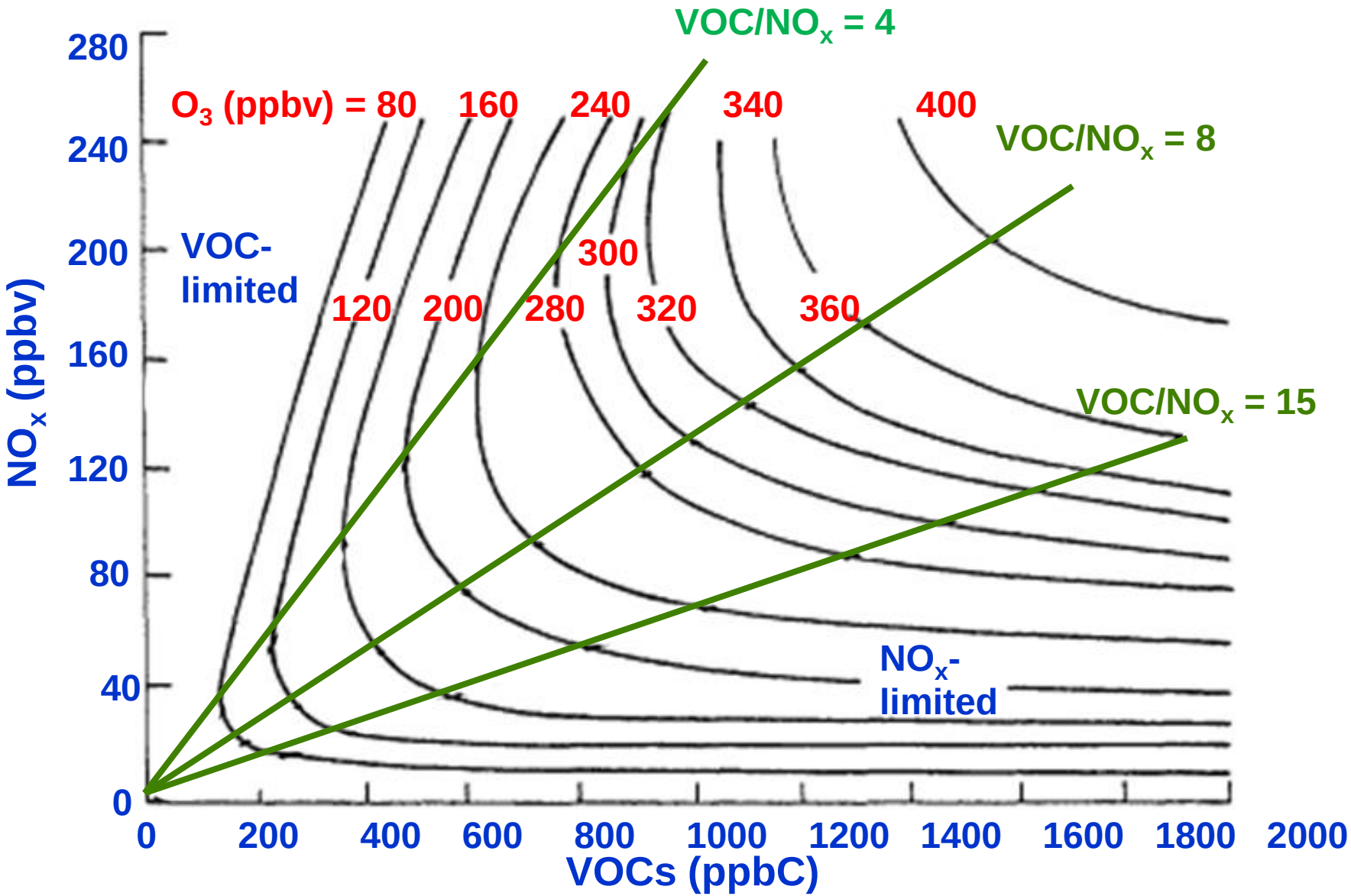
$$NO_x + VOCs \xrightarrow{hv} Ozone$$

HCHO is an oxidation product of most VOCs, so it can serve as a proxy for VOCs.



VOLATILE ORGANIC COMPOUNDS

NO_x + VOCs $\xrightarrow{h\nu}$ O_3 : *Decrease NO_x or VOCs?*



OMI $HCHO/NO_2$ as an Indicator of the Instantaneous Ozone Production Rate (PO_3)

OMI NO_2 → NO_x

OMI $HCHO$ → VOCs

$$NO_x + VOCs \xrightarrow{hv} Ozone$$

**Based on Sillman [1995]*
Martin et al. [2004]

$$VOC/NO_x \sim HCHO/NO_2$$

- If $HCHO/NO_2$ is low, reduce anthropogenic VOCs.
- If $HCHO/NO_2$ is high, reduce NO_x.

NOTE 1: $HCHO/NO_2$ gives info on the sensitivity of PO_3, not the ozone concentration!

NOTE 2: $HCHO/NO_2$ = FNR = Formaldehyde to NO_2 Ratio

“Weight of Evidence” Evaluation

“Weight of Evidence” = data and model results that show that an emission control plan is reducing/will reduce ozone to meet the air quality standard within a certain time.

$\Longrightarrow$ *A trend in the FNR may indicate that an emission control strategy is effective or not.*

$\Longrightarrow$ *The observed FNRs may also be used to define new emission control strategies as the photochemical environments of a region evolve over time.*

OMI FNR: Beijing, China Olympics

- 7-day running average.
- 1°x1° horizontal box over metropolitan area.

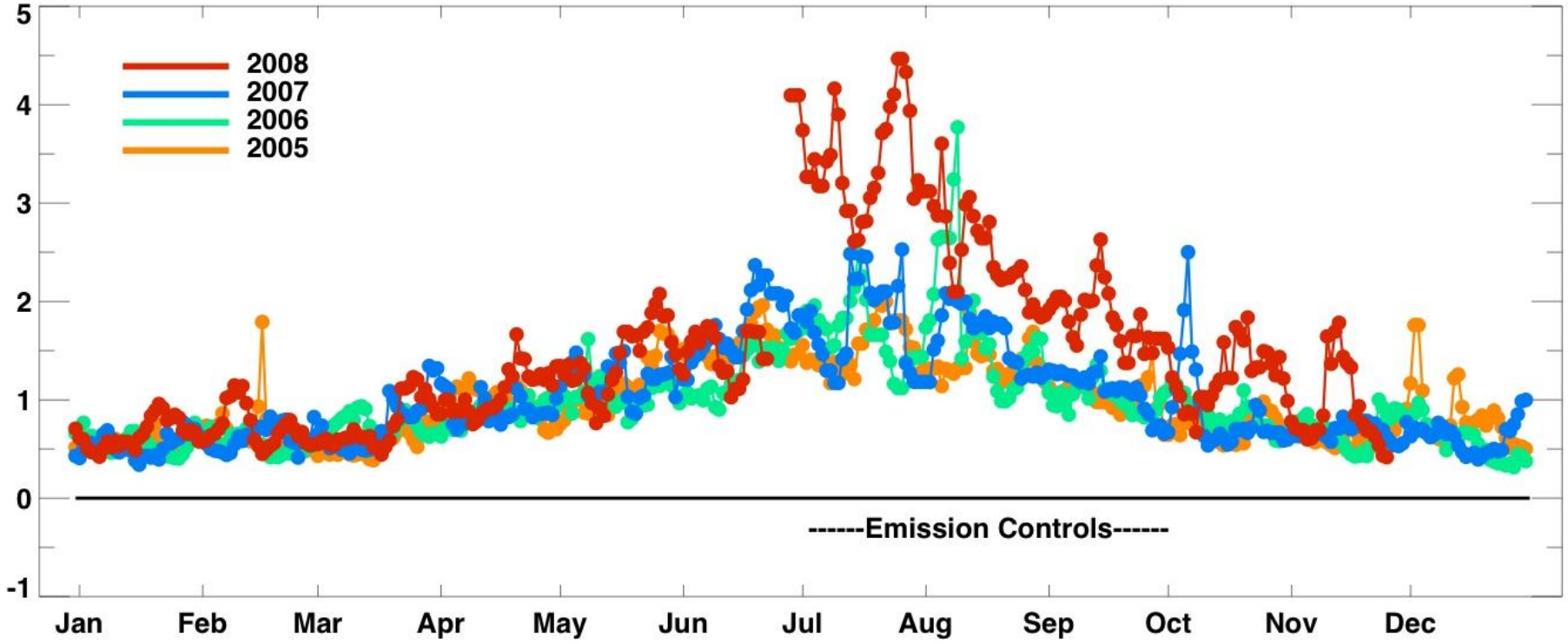
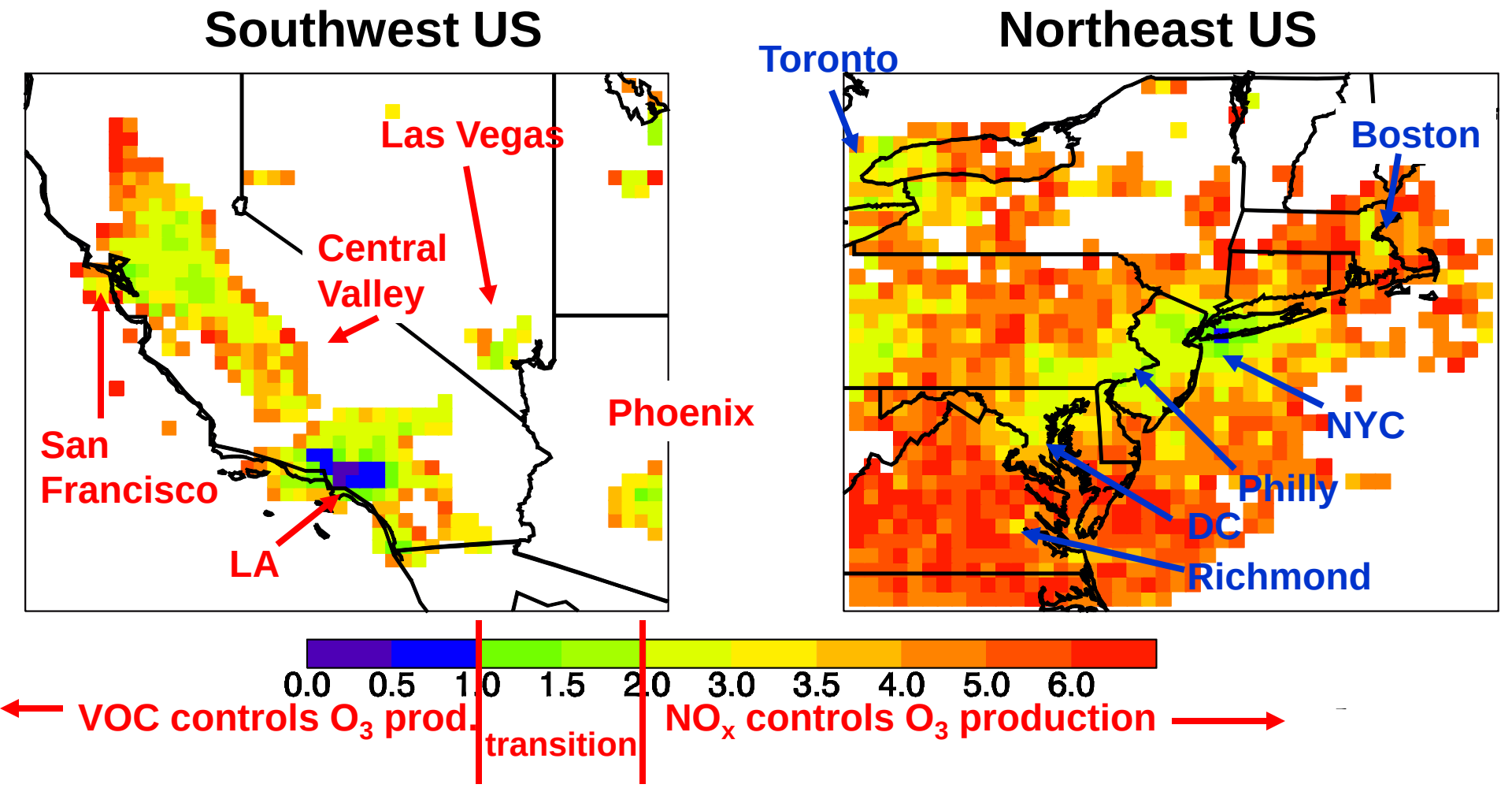


Figure courtesy of Jacquie Witte.

OMI FNR : August 2006



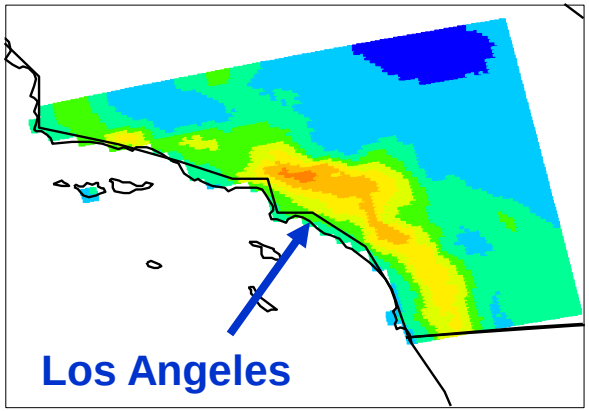
OMI captures gradient from downtown to suburbs to rural areas!

"Proof-of-Concept" Study
CMAQ Simulation : Southern California

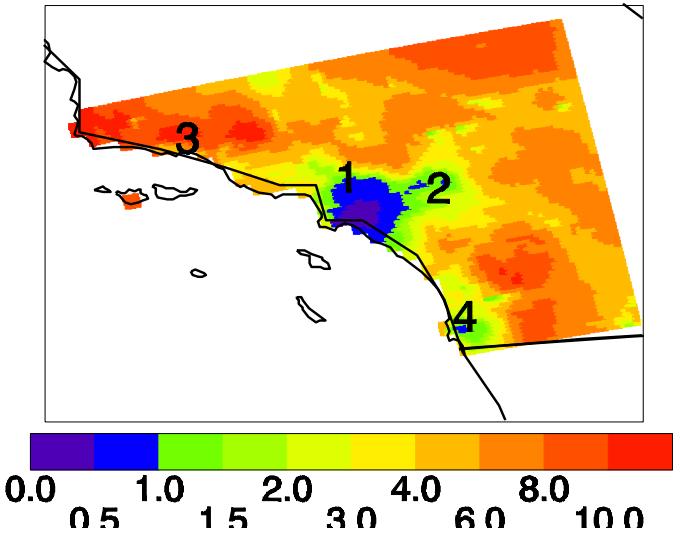
4x4 km^2 horizontal resolution

CMAQ (July 1-4, 2007; 1-3 pm)

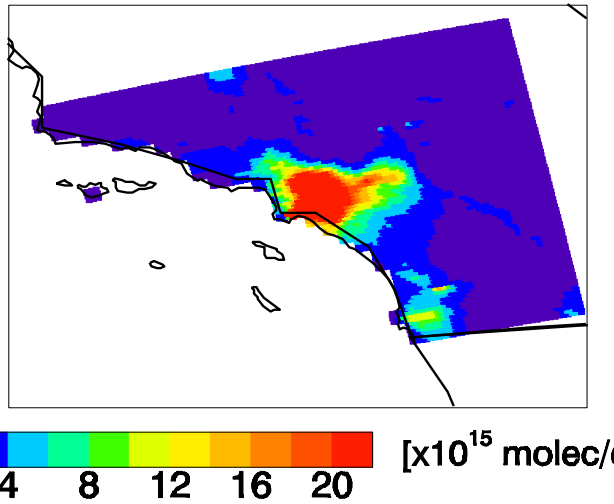
HCHO tropospheric column



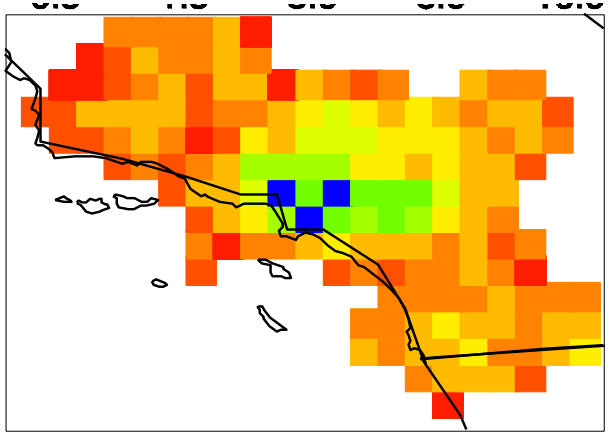
CMAQ FNR



NO_2 tropospheric column



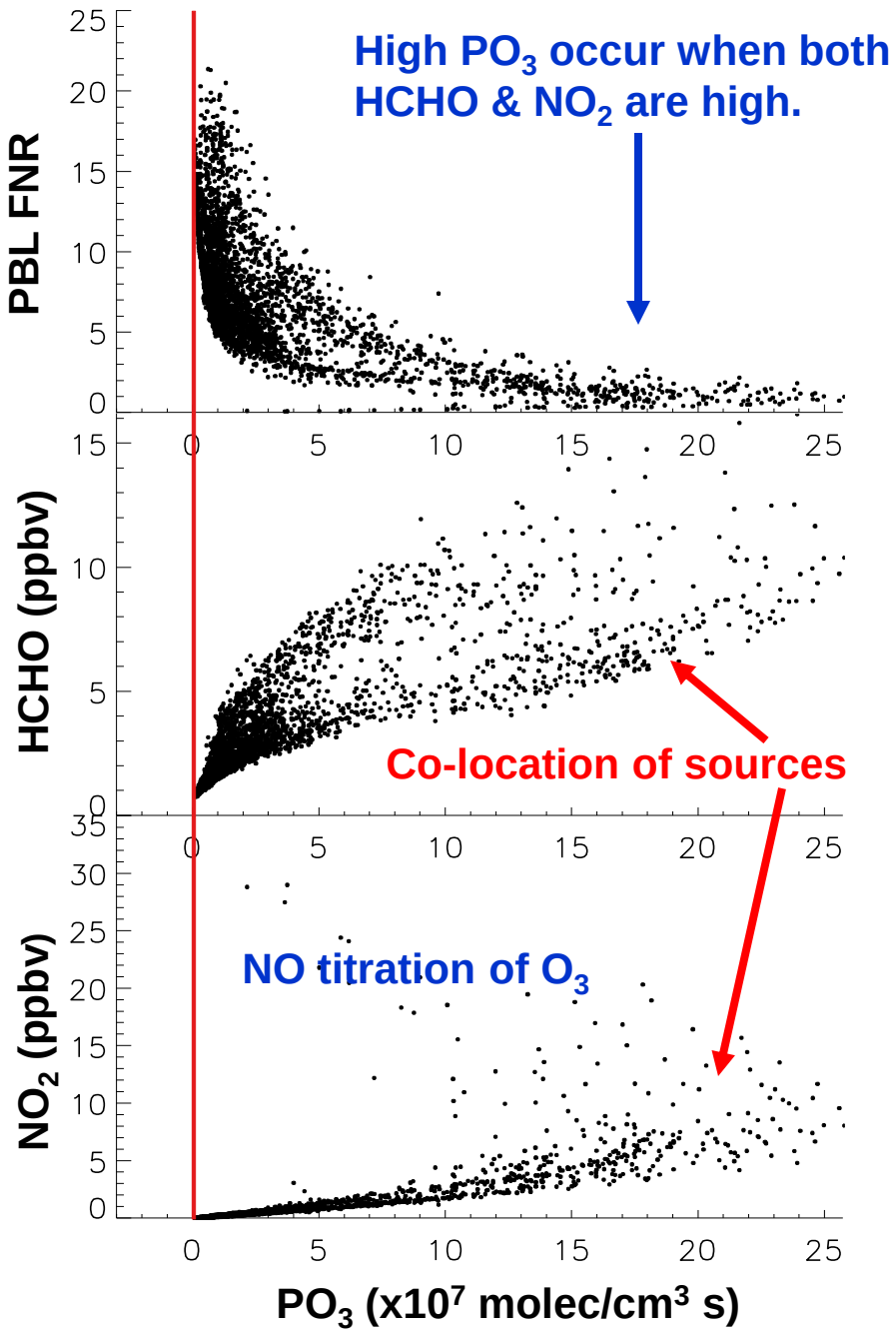
OMI FNR (July 2007)



How does the Instantaneous O_3 Production Rate (PO_3) vary with the PBL FNR, [HCHO], & [NO_2]?

Tropospheric column needs to represent PBL:

Used model columns where >70% of NO_2 and HCHO tropospheric columns in PBL.



Defining the Transition Regime

NO_x-Limited Regime

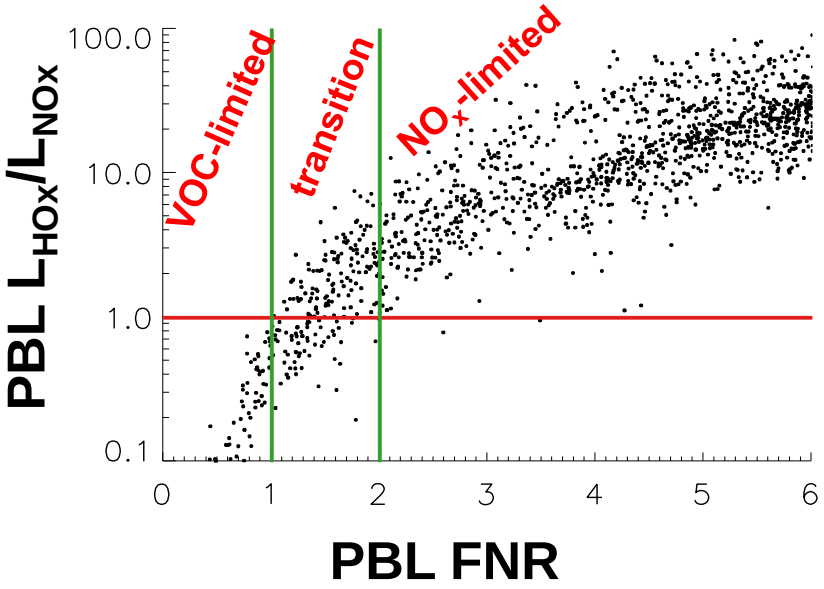
High loss of HO_x (L_{HOx}) (i.e., formation of peroxides = radical sink).

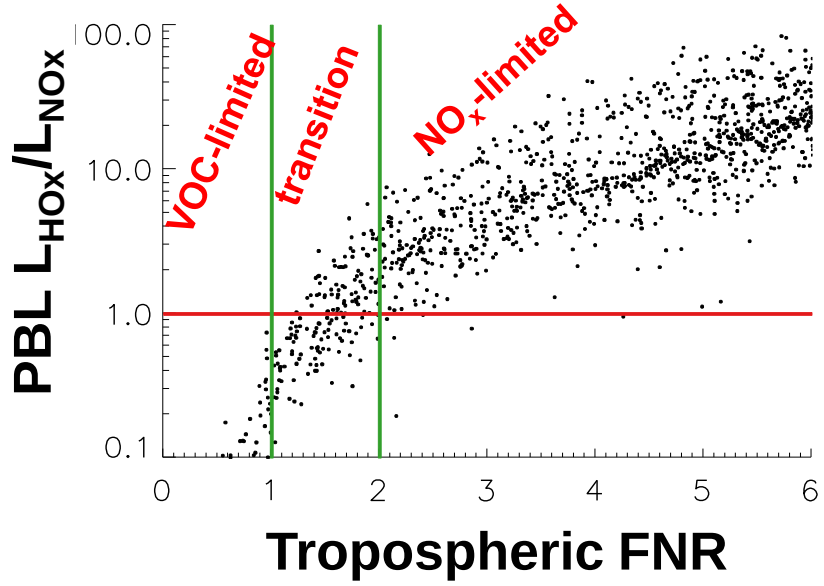
VOC-Limited Regime

High loss of NO_x (L_{NOx}) (i.e., formation of HNO_3 = NO_x sink)

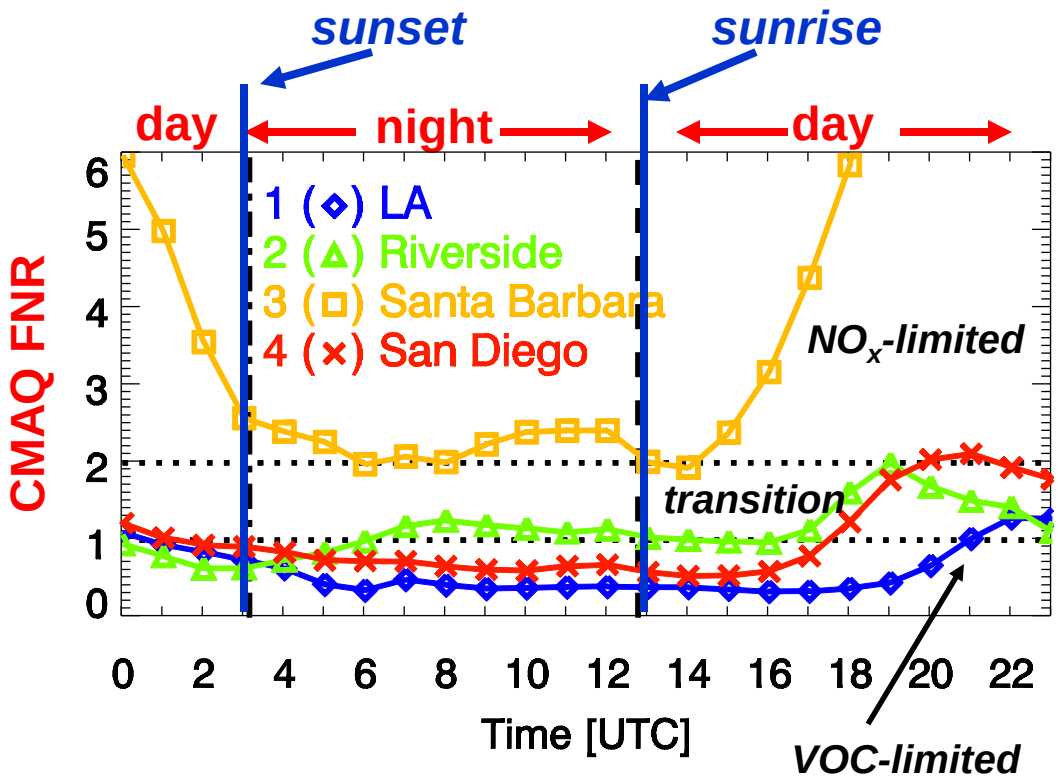
$\therefore L_{HOx}/L_{NOx}$ = 1 is transition between regimes!

Does this definition of the transition regime apply to other cities too?????

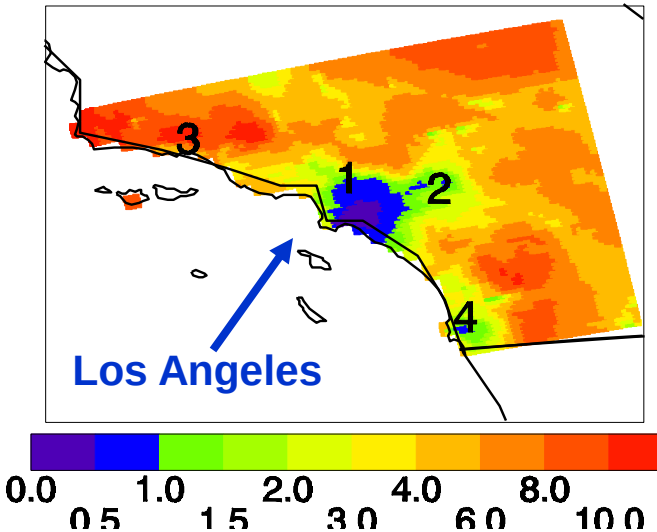




How does the FNR vary throughout the day?



CMAQ FNR (July 1-4, 2007)



- Ozone production can occur under 1, 2 or all 3 photochemical regimes!
- OMI is limited by 1 overpass during daytime.
- Geostationary (e.g., GEO-CAPE) is better for AQ!

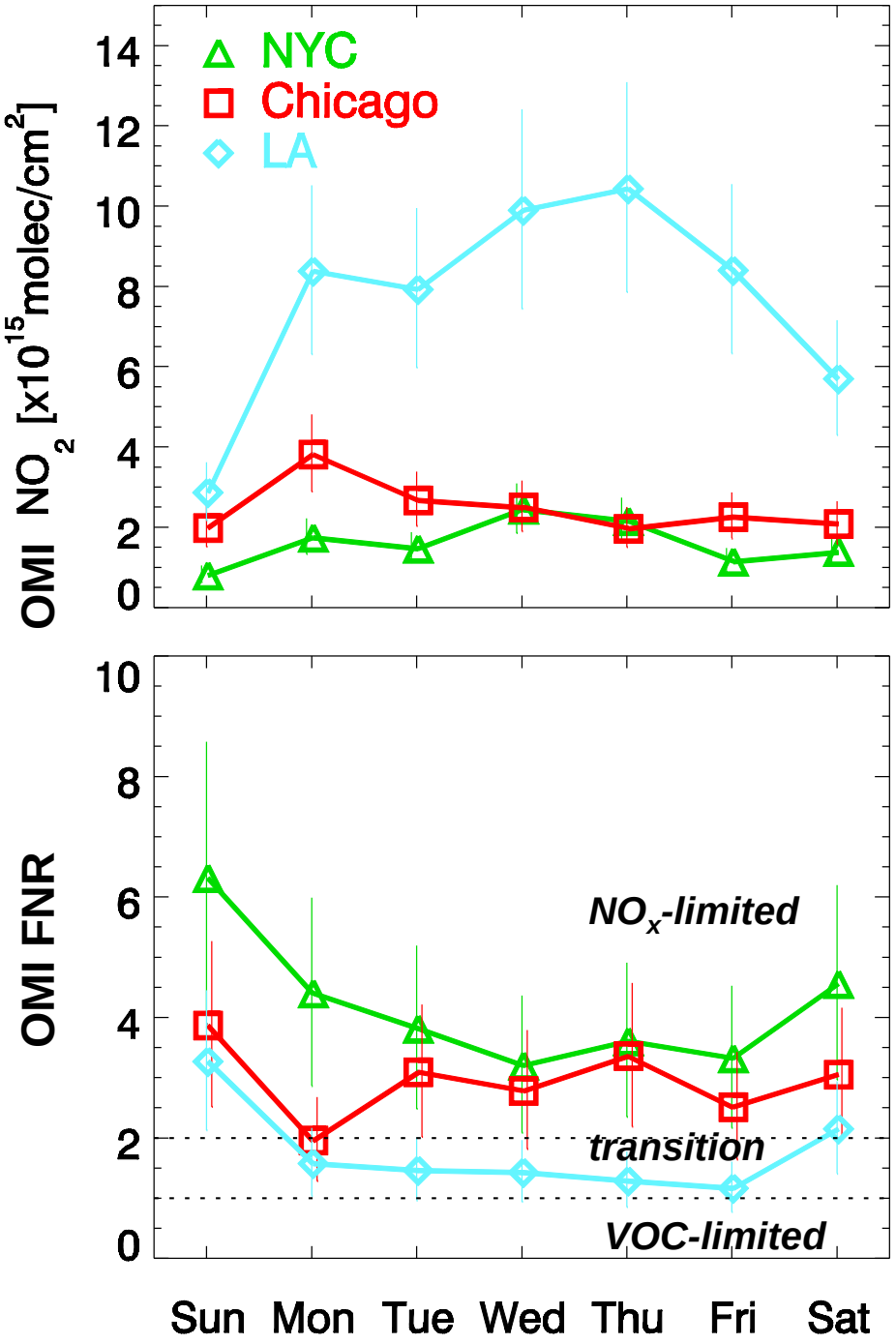
How does the OMI FNR vary throughout the week?

Summer average (JJA 2005-2007) of metropolitan areas.

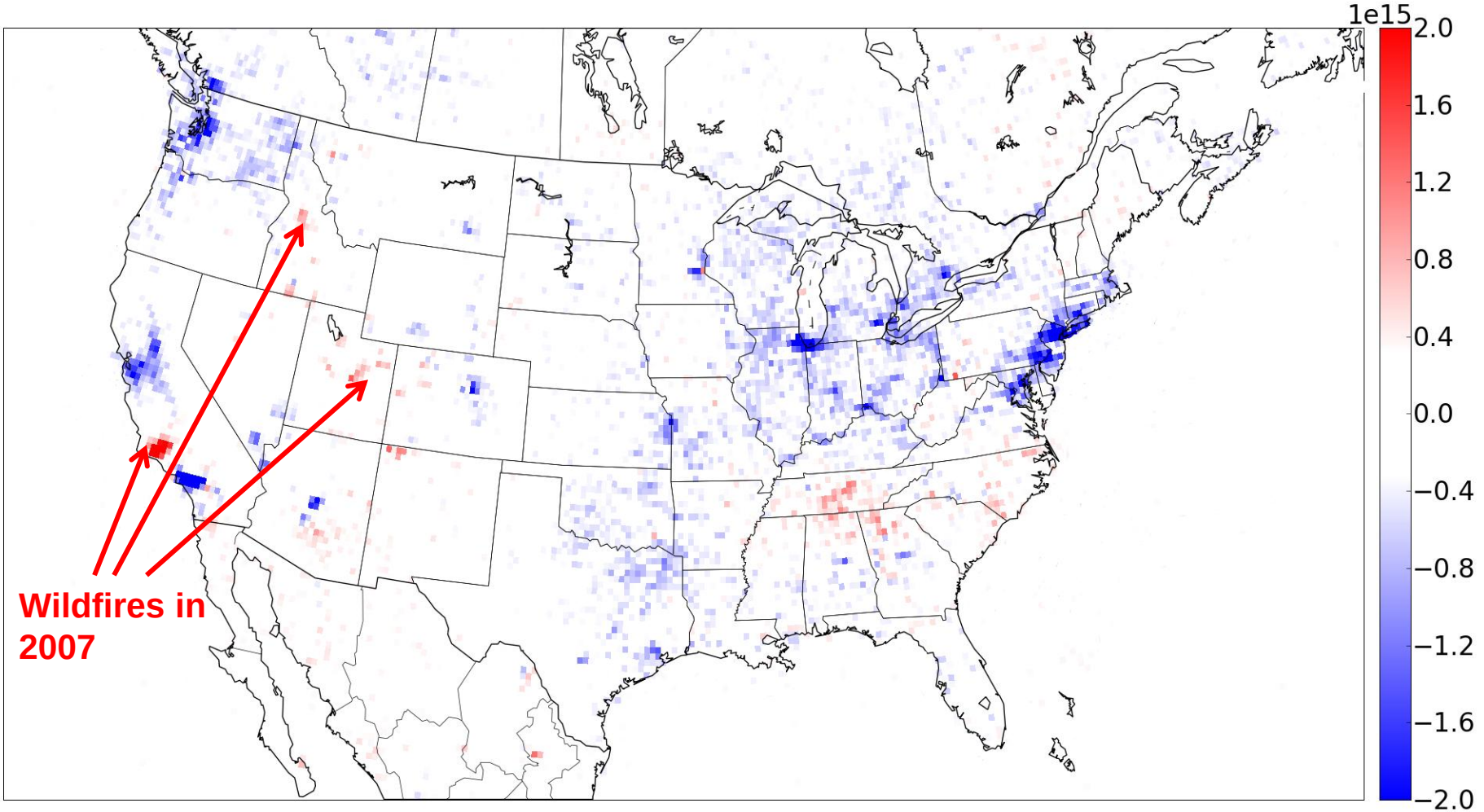
Weekend vs weekday effect.

The LA metropolitan area:
- *transition regime weekdays.*
- *NO_x-limited on weekends.*

Sunday has highest FNR.



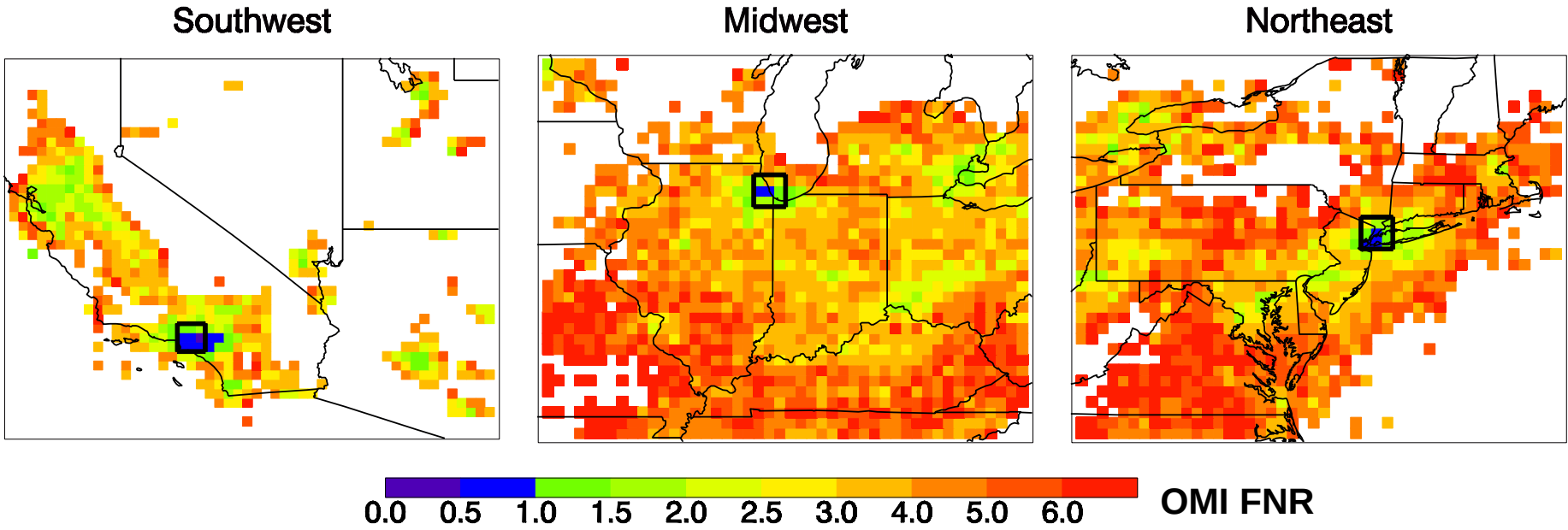
Variability Associated with NO_x Emissions
June-August OMI NO_2: 2007-2005

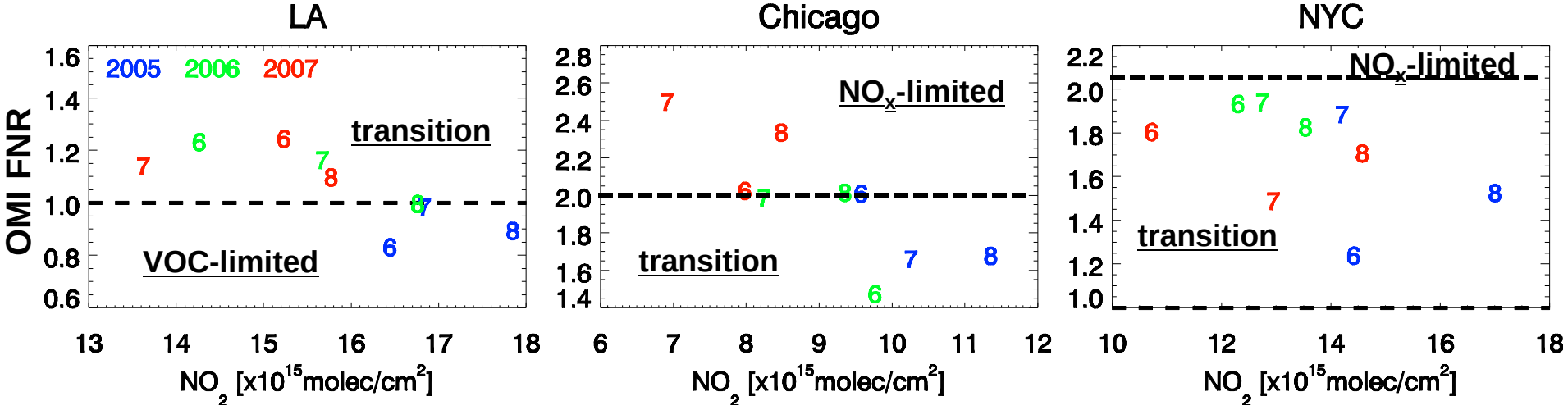


Point sources 10% lower in 2007 due to NO_x Budget Trading Program of EPA.

Automobile emissions decreased due to Tier 2 Vehicle and Gasoline Sulfur Program.

Variability Associated with NO_x Emissions





The FNR is increasing as NO_x emissions decrease.
Therefore, PO_3 is becoming more NO_x-limited.

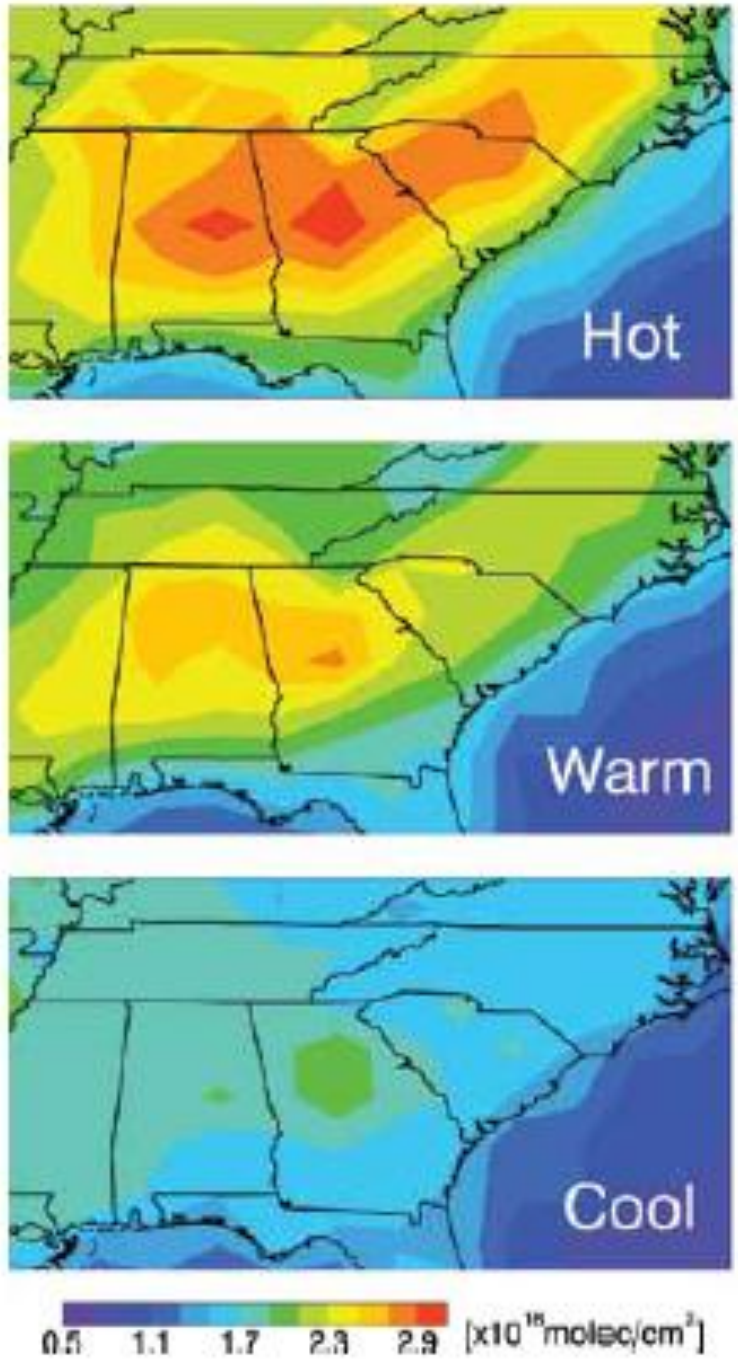
OMI Formaldehyde

Isoprene, a natural VOC, plays an important role in the formation of unhealthy levels of ozone.

Isoprene is emitted from trees.

HCHO is a product of isoprene oxidation, so variation of HCHO can serve as a proxy for variation of isoprene.

Isoprene emissions increase with temperature.



Variability Associated with Isoprene

Isoprene emissions and, subsequently, HCHO increase with temperature.

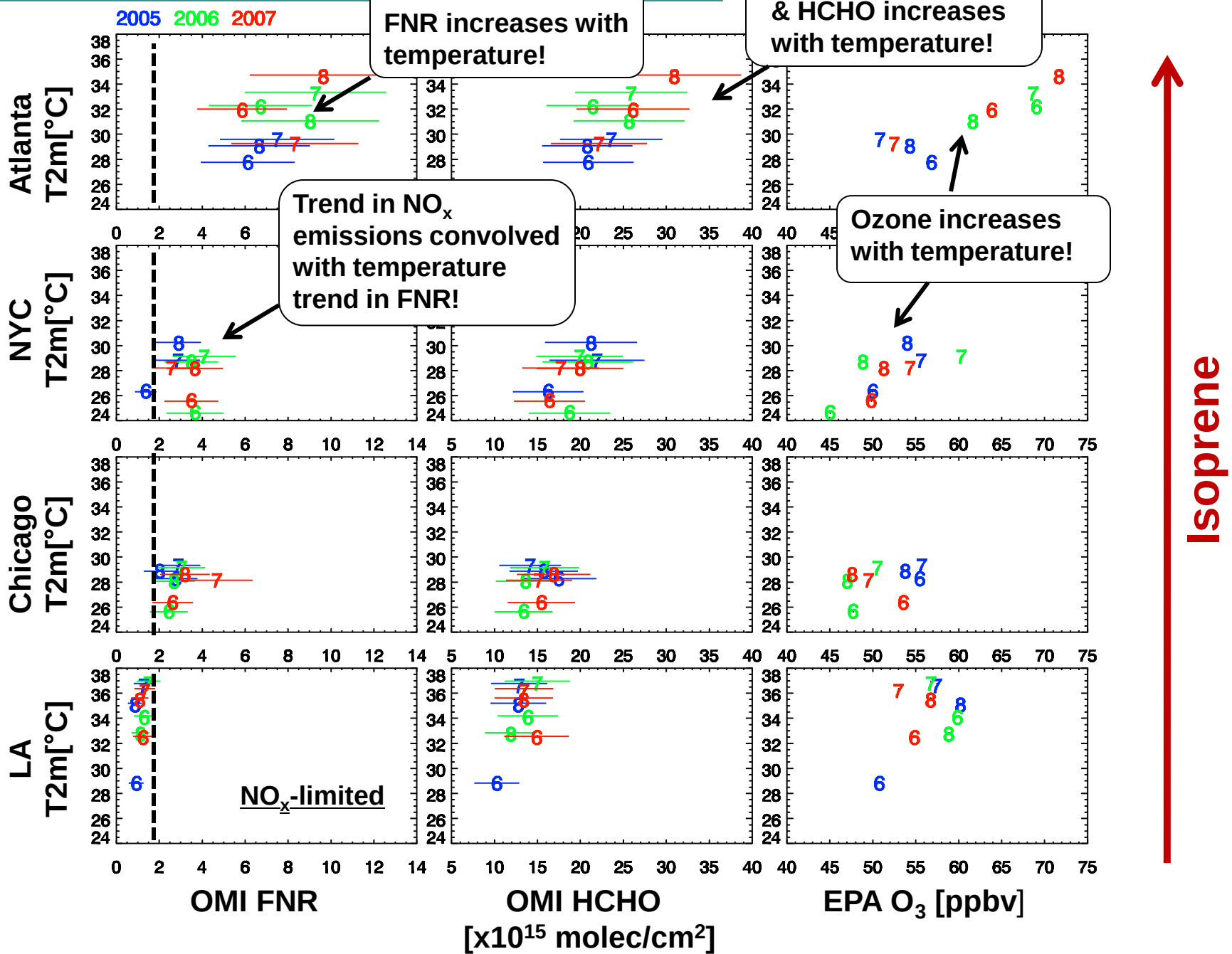
Therefore, FNR should increase with temperature.

We know that the frequency of high O_3 events increase with temperature.

Therefore, ozone formation should be more NO_x-limited during high ozone events.

But, NO_x emissions decreasing!

Variability Associated with Isoprene



Conclusions of "Proof-of-Concept" Study

❑The OMI FNR appears to be a credible air quality indicator and is consistent with *in situ* observations.

❑ The fine horizontal resolution of OMI allows us to see the gradient in the FNR from urban to suburban to rural areas.

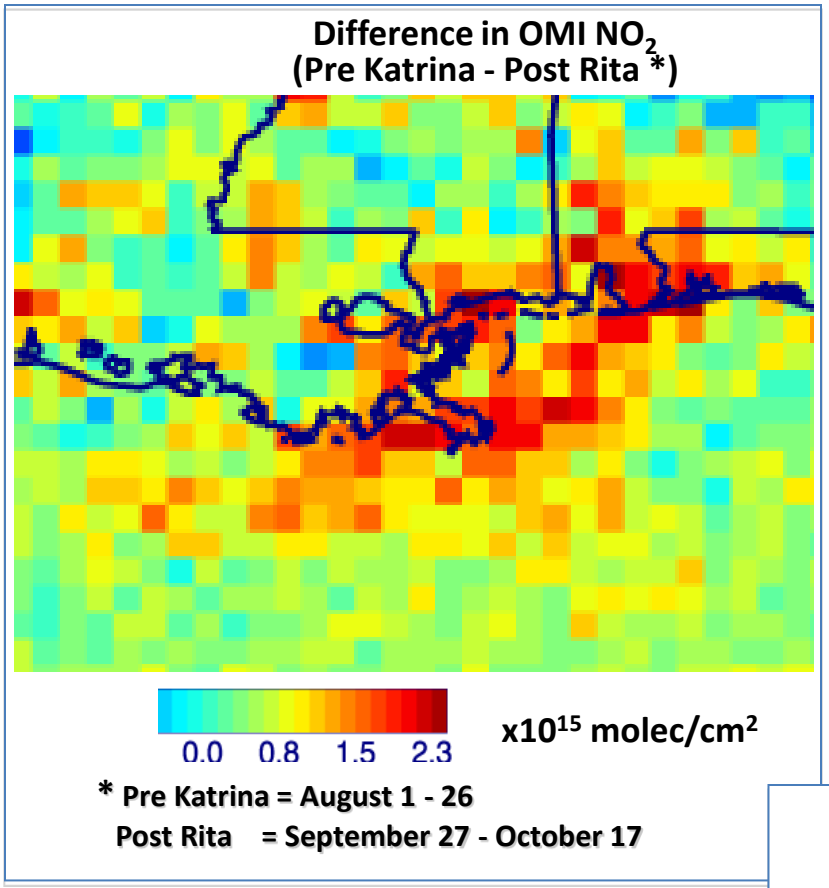
❑ Assuming that our CMAQ results for southern California apply to the entire U.S., the OMI FNR indicates:

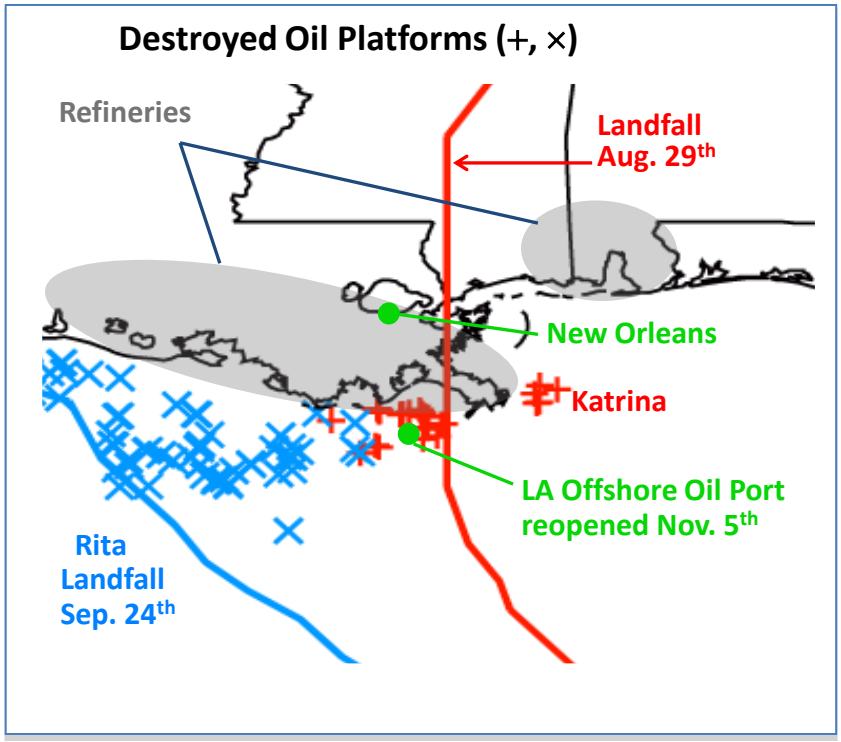
- *Ozone production became more NO_x-limited over the U.S. from 2005-2007 because of substantial NO_x emission reductions.*

- *Ozone production should be more NO_x-limited during heat waves in regions with high biogenic emissions.*

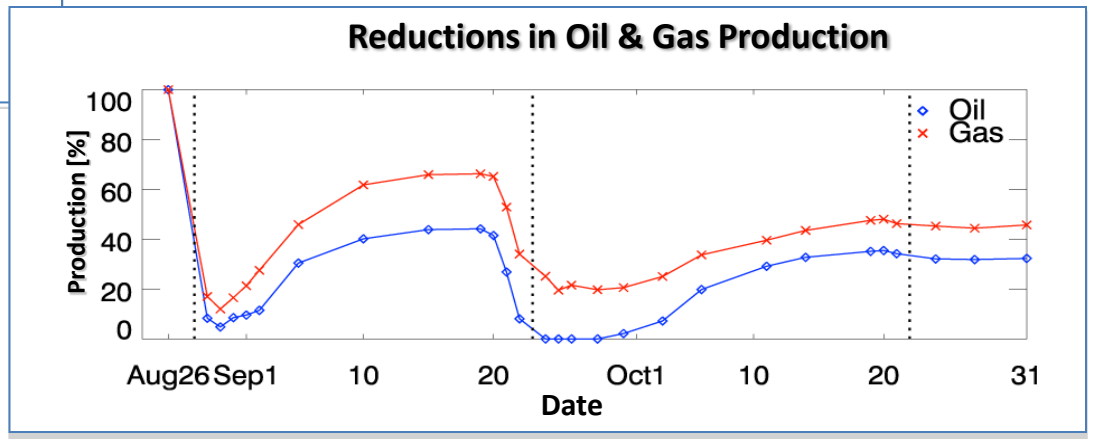
EXTRA SLIDES

The Impact of the 2005 Gulf Hurricanes as Seen by OMI NO_2





Hurricanes Katrina and Rita caused a significant reduction in NO_2 emissions from oil and gas production facilities as well as power plants.



OMI FNR : August 2006